

	<p style="text-align: center;">US ATLAS HL-LHC Upgrade BASIS of ESTIMATE (BoE)</p>	Date of Est: 22-Nov-2015
		Prepared by: Kaushik De (University of Texas/Arlington))
		Docdb #:
WBS number: 6.5.2.3		WBS Title: Tile Calorimeter Preprocessor Interface Boards
<p>WBS Dictionary Definition: This WBS covers the design and fabrication of the Trigger DAQ interface (TDAQi) blades which are the rear transition modules of the Tile calorimeter back-end preprocessor (PPR). These boards configure the processed data from the front-end electronics and route data to the DAQ system via the FELIX module and to the L0/L1 Calo and Muon trigger system through dedicated links.</p> <p>The deliverable for WBS 6.5.2.3 is production of 32 boards. Additional tasks are parts procurement and monitoring of outsourced assembly, burn-in of cards in a dedicated setup with validation testing and repairs when needed.</p>		
<p>Estimate Type (check all that apply – see BOE Report for estimate type by activity):</p> <p> <input type="checkbox"/> Work Complete <input type="checkbox"/> Existing Purchase Order <input type="checkbox"/> Catalog Listing or Industrial Construction Database <input type="checkbox"/> Documented Vendor Estimate based on Drawings/ Sketches/ Specifications <input checked="" type="checkbox"/> Engineering Estimate based on Similar Items or Procedures <input type="checkbox"/> Engineering Estimate based on Analysis <input checked="" type="checkbox"/> Expert Opinion </p>		
<p>Supporting Documents (including but not limited to): Attachments: </p>		

Details of the Base Estimate (explanation of the Work)

This BOE covers the production of 100% of the TDAQi interface blades needed for the detector. The effort includes purchasing components and PCBs for the 32 units needed, and shipping of the boards to CERN.

This estimation are based on the experience acquired by engineers of a collaborating institutes (U. Valencia, Spain) in the construction of the PPR prototype, currently being integrated. More background is provided in the attached document. The TDAQi board design is not specified yet but the components and amount of resources needed can be estimated from similar functionality in the prototype. We expect a complex board with 14 to 16 layers and high performance FPGA, optical links and clocking and memory circuitry.

The design and construction of first prototypes will start at UTA during 2016/2017 and is not included in this WBS. The final design is expected in FY19 and accounted here.

The estimated cost of components and manufacturing for each board amounts to about 6.1k\$ as detailed in the document attached.

Labor FTEs are based on experience from building a prototype for the Tile demonstrator module. The breakdown is as follows:

- Final design: 28% FTE EE in FY19.
- Prototype component selection and BoM: 4% FTE EE in FY20
- Oversee PCB assembly, initial testing, debugging with assy hse: 12% FTE EE in FY20
- Test equipment fabrication: 32% FTE EE, 32% FTE ET in FY20
- Software for control and data analysis in burn in test stand: 4% EE and 24% ET in FY20
- initial testing, debugging: 10% FTE EE in FY20
- Procurement of production components, PCBs, testing: 8% EE in FY21,22
- Oversee PCB assembly, testing, full production: 8% FTE EE in FY21
- Mount in burn-in fixtures; supervise students: 16/8/8% EE, 16/16/8% ET, 52/52% UG in FY21-23
- Diagnose and repair failures: 8/16/8% EE and 36/36/8%ET in FY21-23
- Inventory, crate and ship to CERN: 10% ET in FY23

Travel to CERN by the PI and EE is needed during the production phase to attend expert weeks and to conduct the acceptance tests. We have estimated that two week-long trips per year will be necessary in 2020-23.

A cost summary for the production phase is tabulated below.

WBS	Deliverable	Task	Labor Hrs	Labor \$	M&S \$	Travel \$	Total \$
6.5.2.3	Preprocessor		7,814	473,210	251,600	13,000	737,810
	Preproduction Parts Procurement/Q&A	PPR2020	71	6,178	24,600	0	30,778
	Engineering labor		71				
	Student labor		0				
	Preproduction PCB assembly, QA	PPR2030	213	18,533	0	0	18,533
	Engineering labor		213				
	Student labor		0				
	Test fixture fabrication	PPR2040	1,137	80,927	10,000	0	90,927
	Engineering labor		1,137				
	Student labor		0				
	DAQ & Controls	PPR2050	497	33,977	0	5,000	38,977
	Engineering labor		497				
	Student labor		0				
	Preproduction Board testing	PPR2060	178	15,444	0	0	15,444
	Engineering labor		178				
	Student labor		0				
	Parts Procurement/Q&A	PPR2120	284	25,834	197,000	0	222,834
	Engineering labor		284				
	Student labor		0				
	PCB assembly, QA	PPR2130	142	12,726	0	8,000	20,726
	Engineering labor		142				
	Student labor		0				
	Burn-in	PPR2160	3,126	139,171	0	0	139,171
	Engineering labor		1,279				
	Student labor		1,847				
	Repairs	PPR2170	1,989	130,294	18,000	0	148,294
	Engineering labor		1,989				
	Student labor		0				
	Shipping	PPR2210	178	10,126	2,000	0	12,126
	Engineering labor		178				
	Student labor		0				

Schedule:

The scheduled installation of the Tile Calorimeter modules will begin early in 2024.

The installation of the Barrels and extended barrels modules will be staged in phases and will span over 2024 and 2025. Most notably the PMT blocks currently on the detector have to be decommissioned for the PMTs to be re-used in the new FE modules. The optical fibres trunk cables and Back-End PPR crate installation will follow the same staging scheme. The complete number of TDAQi board for the PPR crates will be ready by the end of 2023. The following timeline is foreseen:

- 2017-2018 production of first prototypes (not covered by this WBS)
- 2019: final design of the TDAQi module-0
- 2020: pre-production of 4 boards, building of test stand and procedures for burn-in and qualification.
- 2021: parts procurement, production and testing of 16 boards
- 2022: parts procurement, production and testing of 16 boards
- 2023: final testing and shipment of boards to CERN
- 2024-2025 installation system test and commissioning (not covered by this WBS)

Assumptions:

- The PPR system will be built by UTA and two non-US collaborating institutes.
- PPR base boards, PPR Processing unit boards, ATCA shelves provided by collaborating institutes.
- The design of the final PPR system is not finalized. This estimation is based on a precise scheme in the final board reading out 8 modules, as detailed in the attachment. Complexity of the TDAQi board and cost might change due to system overall choices and optimization.
- We assume to take responsibility for the 20% of CORE of the PPR that correspond in this design to the full TDAQi system. In case the cost of TDAQi will be inferior the sharing of the components of the PPR between the three institutes might change.
- 10% failure rate in the production process for the cost estimation of material is assumed.
- Design and production of prototypes to be funded by other sources.

Risk Analysis

Schedule Risk:

Probability: Low

Potential Problem: Delay in receiving PPR boards from Valencia.

Mitigation: sufficient float of burn in testing done using commercial emulators.

Cost Risk:

Probability: Low

Potential Problem: change in parts cost (Board is much simplex. FPGA for trigger primitives moved to the base board or PU)

Mitigation: include the procurement of the ATCA systems as UTA sharing of the PPR.

M&S Contingency Rules Applied

50%

We now estimate the contingency based on the rules for M&S. It depends on the maturity of the cost estimate.

5) 40-60% contingency on: items with a detailed conceptual level of design; items adapted from existing designs but with extensive modifications, and/or made more than 2 years previous with documented costs. A physicist or engineering estimate uses this level.

Labor Contingency Rules Applied

50%

We now estimate the contingency based on the rules for Labor.. It depends on the maturity of the cost estimate.

40-60% contingency for a task that is not yet completely defined, but is analogous to past activities; for example, a fabrication activity similar to, but not exactly like, items fabricated for other activities; for example, design labor for items similar to, but not exactly like, previous designs.

Comments:

Attachments:

- UTA plans for the Tilecal PPR:
PPR-Plan-UTA-2015v3.doc
- Detailed spreadsheet with labour and material estimations:
PRP_WBS_UTA_2015_v3.xls
- Detailed bills for components and invoices for the PPR prototype production:
Invoices and bills for components used for the PPR prototype.pdf